(d) (i) the equation of state of an ideal gas
$pV = nRT$, where n is the number of moles

(6) M - Recall the universal molar gas constant
(7) S - Apply the 'equation of state' of an ideal gas.
(8) C - Explain how to see evidence of gas molecules moving at random

Lesson 5. Ideal gas equation

what's different about this problem ?

STARTER: A meteorological balloon has a volume of 6.0m3 when at ground level where the temperature is 293K. The gas in it is at atmospheric pressure 1.0×10^5 Pa. The balloon rises to a height where the pressure has fallen to 4.4×10^4 Pa and the temperature to 257K. Calculate the volume of the balloon at this height.

Kilo 10^3
Mega 10^6
Giga 10^9

Hint: Draw a before and after diagram

Hint: Try to combine the 3 gas law into one.

Key point

Combining the gas laws...

$$\text{constant} = \frac{pV}{T}$$

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

(d) (i) the equation of state of an ideal gas
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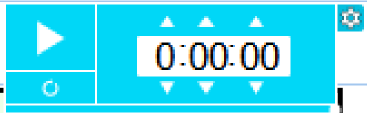
Lesson 5. Ideal gas equation



ACTIVITY: Try **question 4** using this combined relationship.

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

Kilo 10^3
Mega 10^6
Giga 10^9

Try Q1-3 first...

Ex: A fixed mass of gas has a volume of 200cm3 at a temperature of 57C and pressure of 780mm of mercury. Find its volume at STP (0C and 760mm of mercury)

Key point

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{2.5\times10^5\times14}{280} = \frac{1.0\times10^5\times V_2}{293} \qquad (1\ mark)$$

$$V_2 = \frac{2.5\times10^5\times14\times293}{280\times1.0\times10^5} \qquad (1\ mark)$$

$$= 36.625 \qquad (1\ mark)$$

$V_2 = 37\ cm^3$ (to two significant figures) *(1 mark)*

(4 marks)

(6) M - Recall the universal molar gas constant
(7) S - Apply the 'equation of state' of an ideal gas.
(8) C - Explain how to see evidence of gas molecules moving at random

Equation of state for an ideal gas

0:00:00

Key point

$$\text{constant} = \frac{pV}{T}$$

$$\text{constant} = \frac{pV}{T} = nR$$

$$\boxed{pV = nRT}$$

$$R = \frac{pV}{nT}$$

$$\frac{Nm^{-2}m^{3}}{mol\ K} = \frac{Pa\ m^{3}}{mol\ K}$$

$$(kgms^{-2}m^{-2}m^{3})mol^{-1}\ K^{-1}$$

$$kgm^{2}s^{-2}$$

p - Pressure / Pa

V - Volume / m3

T - **Absolute** temperature / K

n - Number of moles mol

R - Molar gas constant (8.31)

Ex: What is the unit for the molar gas constant?

Ans: Jmole-1K-1

Example 1.

A 3.5m3 presurised container contains 425 moles of gas at 25.0C. Calculate the pressure of the gas insider the container.

Step 1: Convert the temperature into kelvin.

25.0°C = 298 K

Step 2: Select the equation you need and rearrange it to make the pressure the subject.

$pV = nRT$, hence $p = \dfrac{nRT}{V}$

Substitute in known values and calculating the pressure of the gas inside the container.

$$p = \frac{425 \times 8.31 \times 298}{3.50} = 3.00 \times 10^5\ \text{Pa (3 s.f.)}$$

(6) M - Recall the universal molar gas constant
(7) S - Apply the 'equation of state' of an ideal gas.
(8) C - Explain how to see evidence of gas molecules moving at random

Lesson 5. Ideal gas equation

ACTIVITY 1: Complete the summary **questions 5-7** on P292.
ACTIVITY 2: Q 8 and 9 on worksheet 7.
ACTIVITY 3: Complete Ex18.2 in 'Lowe'

Kilo 10^3

Mega 10^6

Giga 10^9

Key point

(6) M - Recall the universal molar gas constant
(7) S - Apply the 'equation of state' of an ideal gas.
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Plenary

A rigid cylinder of volume 0.030 m^3 holds 4.0 g of air. The molar mass of air is about 29 g.

a Calculate the pressure exerted by the air when its temperature is 34 °C. [4]

b What is the temperature of the gas in degrees Celsius when the pressure is *twice* your value from part **a**? [4]

Key point

a $PV = nRT$ [1]

$n = \dfrac{4.0}{29} = 0.138$ moles [1]

$P = \dfrac{nRT}{V} = \dfrac{0.138 \times 8.31 \times (273 + 34)}{0.030}$ [1]

$P = 1.17 \times 10^4$ Pa $\approx 1.2 \times 10^4$ Pa (12 kPa) [1]

b $\dfrac{P}{T}$ is constant when the volume of the gas is constant. [1]

The pressure is doubled, hence the absolute temperature of the gas is also doubled. [1]

Therefore:

temperature $= 2 \times (273 + 34) = 614$ K [1]

temperature in °C $= 614 - 273 = 341$ °C ≈ 340 °C [1]